# Comparison the leaf essential oils of the cultivated fastigiate (strict) growth forms of *Cupressus sempervirens* in California and Turkey

**Robert P. Adams**
Biology Department, Baylor University, Box 97388, Waco, TX
76798, USA, Robert_Adams@baylor.edu

**Tuğrul Mataraci**
Eskidji Müz. AŞ., Sanayi Cad. Vadi Sokak No:2, Tarabya, İstanbul, Turkey

and

**Jim A. Bartel**
San Diego Botanic Garden, P. O. Box 230005, Encinitas, CA 92023

## ABSTRACT

The volatile leaf oils of *Cupressus sempervirens* fastigiate (strict) cultivars from California, USA, and Turkey were analyzed and compared. The volatile leaf oils of cultivated fastigiate growth forms are dominated by α-pinene (27.4 - 65.7%), δ-3-carene (0.2 - 30.1%) and manoyl oxide (0.1 - 9.1%), with moderate amounts of myrcene (2.1 - 2.6%), terpinolene (1.4 - 4.7%), α-terpinyl acetate (1.1 - 4.7%), iso-pimara-7,15-diene (0.3, 1.2%), isoabienol (0.9, 6.0%), and trans-totarol (0.8 - 5.5%). Cedrol was found to be very variable, ranging from none to 7.6%. Cultivars 'Glauca', 'Stricta', 'Tiny Tower', and 'Totem' were each distinct in one or a few components of their oils, but otherwise nearly identical qualitatively and quantitatively. The slight variation in oils (in both California and Turkey cultivars) indicative that there have been multiple selections for the strict or fastigiate habit throughout history. No general suite of compounds distinguished California and Turkey strict cultivars. In spite of the slight differences in the leaf volatile oils, three commercial California cultivars ('Glauca', 'Tiny Tower', and 'Totem') are quite different in their foliage. Published on-line www.phytologia.org *Phytologia 99(2): 89-94 (May 9, 2017).* ISSN 030319430.

**KEY WORDS**: *Cupressus sempervirens,* 'Glauca', 'Stricta', 'Tiny Tower', 'Totem', terpenoids.

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C*upressus sempervirens* L.; referred to as Mediterranean, common, Italian, cemetery, graveyard, or Tuscan cypress; ranges naturally from the eastern Mediterranean, Crete, Cyprus, eastern Aegean Islands, Iran, Israel, Jordan, Lebanon, Syria, Turkey, and possibly Libya (Sękiewicz et al. 2016). Despite having fastigiate (strict) and horizontal forms in the Old World that have been variously taxonomically treated, Farjon (2010) concluded that the widely cultivated fastigiate forms or "cultigens" common throughout the Mediterranean are not a taxonomic variety. The species has been widely cultivated within and outside its range throughout the warm temperate world (More and White 2002). The fastigiate or 'Stricta' form or cultivar is widely planted throughout the world.

The volatile leaf essential oils of *Cupressus sempervirens* have been analyzed based mostly on locally cultivated fastigiate trees. The report by Ulukanli et al. (2014) is typical reporting the major components being: α-pinene (35.6%), trans-pinocarveol (5.22%), α-phellandrene-8-ol (4.56%), β-pinene (3.1%), limonene (2.8%), borneol 2.3%) and camphene (2.2%). Chanegriha, et al. (1977) reported on the leaf oils of *C. sempervirens* from Algeria, likely from a cultivated plant, as having α-pinene (44.9%), δ-3-carene (10.6%), limonene (4.5%), terpinolene (2.7%), terpin-4-ol (1.9%), α-terpinyl acetate (12.0%) and manoyl acetate (1.5%). Floreani et al. (1981) reported the essential oil of cv. 'Stricta' (Argentina) contained α-pinene (50.1%), camphene (1.4%), β-pinene (4.1%), δ-3-carene (30.5%), limonene (3.5%),

terpinolene (1.3%) and α-terpineol (1.6%). Other reports are by Adams et al. (1997), Amri et al. (2013), Pauly et al. (1983), Floreani et al. (1982) and Gamero et al. (1978)

Recently, Adams et al. (2017) reported on the leaf essential oils from *Cupressus sempervirens* from both fastigiate and horizontal forms. They found the oils did not differ sufficiently between the two forms to justify the recognition of varieties.

The purpose of the present paper is to report on variation the volatile leaf oils of additional commercial cultivars of the fastigiate forms from California, USA, and compare their oils with those of cultivated trees of the fastigiate forms from Montenegro and Turkey.

## MATERIALS AND METHODS

Plant materials:
See Adams et al. (2017) for collection information concerning samples of cv. 'Stricta' from Turkey (*Adams 14597, 14647, 14648, 14675*).
cultivated, Carlsbad, CA, approx. 33° 06' 56.6" N, 117° 18' 39.3" W, 151ft, 17 July 2015, San Diego Co.:
Coll. *Jim A. Bartel 1631,* cv. 'Stricta', Lab Acc. *Robert P. Adams 14591,* oil type I, planted ca. 1985,
Coll. *Jim A. Bartel 1632,* cv. 'Glauca', Lab Acc. *Robert P. Adams 14592,* oil type II, planted ca. 2005,
Coll. *Jim A. Bartel 1633,* cv. 'Stricta' or 'Glauca', Lab Acc. *Robert P. Adams 14593,* oil type I, planted ca. 2000,
Coll. *Jim A. Bartel 1634,* cv. 'Glauca', Lab Acc. *Robert P. Adams 14594,* oil type II, planted ca. 1980,
Coll. *Jim A. Bartel 1635,* cv. 'Glauca', Lab Acc. *Robert P. Adams 14595,* oil type I, planted ca. 2010,
*C. sempervirens* cv. 'Tiny Tower,' cult. Carlsbad, CA Dec 8, 2016, Coll. *Jim A. Bartel 1637,* Lab Acc. *Robert P. Adams 15057,* planted ca. 2013.
*C. sempervirens* cv. 'Glauca', cult. Carlsbad, CA, Dec 8, 2016, Coll. *Jim A. Bartel 1638,* Lab Acc. *Robert P. Adams 15058,* planted ca. 2010.
*C. sempervirens* cv. 'Totem', purchased in 1 gal. container, Green Thumb Super Garden Center, Carlsbad, CA, Dec 8, 2016, Lab Acc. *Robert P. Adams 15059*
All specimens are deposited in the BAYLU herbarium.

Isolation of Oils - Fresh leaves (200 g) were steam distilled for 2 h using a circulatory Clevenger-type apparatus (Adams, 1991). The oil samples were concentrated (ether trap removed) with nitrogen and the samples stored at -20ºC until analyzed. The extracted leaves were oven dried (100ºC, 48 h) for determination of oil yields.

Chemical Analyses - The oils were analyzed on a HP5971 MSD mass spectrometer, scan time 1 sec., directly coupled to a HP 5890 gas chromatograph, using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column (see 5 for operating details). Identifications were made by library searches of our volatile oil library (Adams, 2007), using the HP Chemstation library search routines, coupled with retention time data of authentic reference compounds. Quantitation was by FID on an HP 5890 gas chromatograph using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column using the HP Chemstation software.

## RESULTS AND DISCUSSION

The volatile leaf oils of cv. 'Stricta' are dominated by α-pinene (27.4 - 65.7%), δ-3-carene (0.2 - 30.1%) and manoyl oxide (0.1 - 9.1%), with moderate amounts of myrcene (2.1 - 2.6%), terpinolene (1.4

- 4.7%), α-terpinyl acetate (1.1 - 4.7%), iso-pimara-7,15-diene (0.3, 1.2%), isoabienol (0.9, 6.0%), and trans-totarol (0.8 - 5.5%) (Table 1). Cedrol was found to be most variable ranging from none to 7.6%.

The oils compositions of samples of *C. sempervirens* cv. 'Stricta' or 'Glauca' growing near San Diego, CA, USA proved to very uniform, but two oil types (Type I, II), are seen (Table 1) by their differences in: linalool (0.4%, trace); germacrene D (0.6, 1.6%) and abienol (2.3, 0.7%). Otherwise, the oils are nearly identical. As a group, Types I and II are distinguished from the other California cultivars by their higher amounts of manoyl oxide (7.0 - 9.1% vs. 0.1 - 3.3% in 'Totem', 'Glauca', and 'Tiny Tower,' Table 1).

The oil of cv. 'Totem' is distinguished (Table 1) by high amounts of α-thujene (0.5%), sabinene (5.4%), karahanaenone (0.3%), unknown terpene alcohol (KI1264, 0.2%) and isoabienol (6.0%). In addition, cv. 'Totem' has low amounts of iso-pimara-8(14), 15-diene (0.1%), manoyl oxide (0.1%), and iso-pimara-7,15-diene (0.1%).

The oil of cv. 'Glauca' has no very distinguishing components, except karahanaenone (0.3%) (which it has in common with cv. 'Totem' (Table 1).

The oil of cv. 'Tiny Tower' is distinct by its linalool (2.5%) and camphor (0.3%, Table 1).

Nothing in the leaf oils of the cultivars from Turkey separate them from cultivars in California (Table 1). However, the 'Stricta' Turkey *14597* sample was unusual in having a high concentration of α-pinene (65.7%), and very low concentrations of δ-3-carene (0.2%), linalool (trace), α-cedrene (none), β-cedrene (0.1%), cedrol (trace) and abietadiene (trace).

Jacobson (1996) noted that the introduction of the fastigiate Italian cypress into North America is unknown, but George Washington planted one at Mt. Vernon in 1786. It seems very probable that Italian cypress was introduced into Mexico by the Spaniards much earlier, as it is universally planted at churches and cemeteries in Mexico. Jacobson (1996) lists the introductions of known cultivars as:
cv. 'Glauca Stricta' ≤ 1934; cv. 'Stricta' date uncertain; cv. 'Swane's Golden' ≤1977-78 by Swane Bros. Nursery, Australia; cv. 'Totem' ≤1992, ex Duncan & Davies nursery, NZ; cv. 'Variegata' ≤1930s likely from England ca. 1848.

The commonly cultivated Italian cypress around San Diego, CA appears to be cv. 'Glauca Stricta.' In spite of the slight differences in the leaf volatile oils, the three commercial cultivars ('Tiny Tower,' 'Glauca' and 'Totem') are quite different in their foliage (Fig. 1).


Figure 1. Fresh foliage of cultivars 'Tiny Tower,' 'Glauca' and 'Totem'. Note the variation in color and leaf shapes.

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Table 1. Leaf essential oil compositions for *Cupressus sempervirens* taxa. Compounds in bold show large differences between samples. The oil of Type 1 (14591) was the same as for samples 14593, 14595. The oil of Type 2 (14592) was the same as for sample 14594.

| | | strict cultivars from California, USA | | | | | strict cultivars from Turkey | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| KI | compound | Stricta Type 1 14591 | Stricta Type 2 14592 | cv. Totem 14059 | cv. Glauca 15058 | cv. Tiny Tower 15057 | Stricta Istan. 14674 | Stricta Turk. 14647 | Stricta Turk. 14648 | Stricta Turk. 14597 |
| 921 | tricyclene | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | t | 0.1 | 0.1 |
| 924 | α-thujene | 0.1 | t | 0.5 H | 0.1 | 0.1 | 0.5 H | 0.1 | t | t |
| 932 | α-pinene | 41.2 | 38.2 | 27.8 | 32.5 | 39.6 | 34.4 | 28.5 | 35.2 | 65.7 H |
| 945 | α-fenchene | 0.6 | 0.5 | 1.0 | 0.6 | 0.7 | 0.6 | 0.8 | 0.9 | 0.1 |
| 946 | camphene | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 |
| 969 | sabinene | 0.7 | 0.7 | 5.4 H | 0.6 | 1.0 | 3.4 H | 0.4 | 0.4 | 1.0 |
| 974 | β-pinene | 1.1 | 1.1 | 1.2 | 1.0 | 1.1 | 1.1 | 1.1 | 0.9 | 1.9 |
| 988 | myrcene | 2.2 | 2.1 | 2.8 | 2.2 | 2.3 | 2.4 | 2.3 | 2.3 | 2.6 |
| 1002 | α-phellandrene | t | t | t | t | t | t | t | t | t |
| 1008 | δ-3-carene | 17.1 | 15.8 | 24.7 | 18.3 | 16.5 | 17.3 | 30.1 | 25.7 | 0.2 L |
| 1014 | α-terpinene | 0.2 | 0.1 | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | t |
| 1020 | p-cymene | t | t | t | t | t | 0.1 | 0.1 | t | t |
| 1023 | sylvestrene | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | t |
| 1024 | limonene | 1.8 | 2.3 | 1.4 | 2.2 | 2.1 | 1.0 | 1.0 | 0.8 | 1.4 |
| 1025 | β-phellandrene | 1.3 | 1.4 | 1.0 | 1.5 | 1.5 | 0.9 | 1.0 | 0.7 | 1.3 |
| 1044 | (E)-β-ocimene | 0.1 | 0.2 | t | 0.1 | t | 0.1 | 0.1 | 0.1 | 0.1 |
| 1054 | γ-terpinene | 0.3 | 0.3 | 0.7 | 0.3 | 0.4 | 0.4 | 0.2 | 0.3 | 0.2 |
| 1067 | linalool oxide | t | t | 0.2 | 0.1 | 0.1 | t | t | t | t |
| 1086 | terpinolene | 3.9 | 4.2 | 4.7 | 3.6 | 3.2 | 3.2 | 3.2 | 4.4 | 1.4 |
| 1099 | linalool | 0.4 | t | 0.6 | 0.5 | 2.5 H | 0.3 | 0.6 | t | t |
| 1118 | cis-p-mentha-2-en-1-ol | t | t | 0.1 | t | 0.1 | t | 0.1 | 0.1 | t |
| 1123 | α-camphenal | t | t | - | t | 0.1 | t | 0.1 | t | t |
| 1136 | trans-p-mentha-2-en-1-ol | t | t | 0.1 | t | 0.1 | t | t | t | t |
| 1141 | camphor | - | t | - | - | 0.3 H | t | t | t | t |
| 1154 | karahanaenone | - | - | 0.3 H | 0.3 H | - | t | t | t | t |
| 1067 | umbellulone | - | - | 0.5 H | - | - | t | t | t | t |
| 1174 | terpinen-4-ol | 0.9 | 0.6 | 1.8 H | 1.0 | 1.0 | 0.6 | 0.6 | 0.3 | 0.2 |
| 1179 | p-cymen-8-ol | t | t | t | t | t | t | 0.1 | t | t |
| 1186 | α-terpineol | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | t | 0.2 | 0.1 | t |
| 1204 | verbenone | - | - | t | t | t | t | 0.2 | 0.1 | t |
| 1241 | carvacrol, methyl ether | t | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 1.0 | t |
| 1264 | terpene alcohol, FW152 | t | - | 0.2 H | t | t | t | t | t | t |
| 1287 | bornyl acetate | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 | 0.4 | 0.2 | 0.1 | t |
| 1295 | terpinyl acetate, FW196 | - | - | 0.2 | 0.2 | 0.2 | t | t | t | t |
| 1315 | <2E,4E->decadienal | 0.1 | t | 0.1 | 0.2 | 0.2 | t | t | t | t |
| 1334 | linalool propionate | 0.5 | 0.4 | 0.9 | 0.9 | 0.9 | 0.4 | 1.3 | 0.7 | t |
| 1346 | α-terpinyl acetate | 2.1 | 2.1 | 3.4 | 4.7 | 4.7 | 1.5 | 4.4 | 2.8 | 1.1 |
| 1410 | α-cedrene | 0.1 | 0.1 | NONE | 0.1 | 0.1 | 0.1 | t | NONE | NONE |
| 1411 | 2-epi-β-funebrene | 0.1 | 0.1 | NONE | 0.1 | 0.1 | 0.1 | t | NONE | NONE |
| 1417 | (E)-caryophyllene | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | t | 0.1 |
| 1419 | β-cedrene | 0.1 | 0.1 | NONE | 0.1 | 0.1 | 0.2 | 0.3 | t | 0.1 |
| 1448 | cis-muurola-3,5-diene | t | 0.1 | 0.1 | t | t | 0.1 | t | 0.6 | 0.2 |
| 1452 | α-humulene | t | 0.1 | 0.2 | t | t | 0.2 | 0.3 | t | 0.2 |
| 1465 | cis-muurola-4(14),5-diene | 0.2 | 0.3 | 0.2 | t | t | 0.3 | 0.2 | 1.5 | 0.5 |
| 1478 | γ-muurolene | - | - | - | t | t | t | 0.1 | t | 0.2 |
| 1480 | germacrene D | 0.6 | 1.6 | 1.1 | 0.3 | 0.3 | 4.1 | 1.2 | 0.6 | 3.5 |
| 1499 | epi-zonarene | - | - | - | - | - | t | t | 0.6 | t |
| 1500 | α-muurolene | t | t | - | t | t | t | t | t | 0.3 |
| 1513 | γ-cadinene | t | t | - | t | t | t | t | t | t |
| 1521 | trans-calamenene | t | t | - | t | t | 0.1 | 0.1 | 0.3 | 0.2 |
| 1522 | δ-cadinene | t | t | - | t | t | 0.1 | 0.2 | 0.2 | 0.2 |
| 1550 | cis-muurola-5-en-4-β-ol | t | t | 0.1 | t | t | t | t | t | t |
| 1559 | cis-muurola-5-en-4-α-ol | t | 0.1 | 0.1 | 0.1 | 0.1 | t | t | t | t |
| 1600 | cedrol | 3.5 | 5.2 | NONE | 7.6 | 7.6 | 6.2 | 1.6 | NONE | t L |
| 1652 | α-cadinol | 0.2 | 0.4 | 0.3 | 0.1 | 0.1 | 0.4 | 0.7 | 1.3 | 1.3 |
| 1685 | germacra-4(15),5,10(14)-trien-1-al | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 1.0 | 0.3 | 0.3 |

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|---|---|---|---|---|---|---|---|---|---|---|
| KI | compound | *Stricta* Type 1 14591 | *Stricta* Type 2 14592 | cv. Totem 14059 | cv. Glauca 15058 | cv. Tiny Tower 15057 | Stricta Istan. 14674 | Stricta Turk. 14647 | Stricta Turk. 14648 | Stricta Turk. 14597 |
| 1930 | diterpene, FW272 | t | t | 0.3 H | t | t | t | t | t | t |
| 1958 | iso-pimara-8(14),15-diene | 0.5 | 0.6 | 0.1 L | 0.3 | 0.3 | 0.4 | 0.6 | 1.2 | 0.4 |
| 1987 | manoyl oxide | 7.0 H | 9.1 H | 0.1L | 3.3 | 3.3 | 0.2 | 1.3 | 0.7 | 2.0 |
| 1987 | iso-pimara-7,15-diene | 1.9 | 2.7 | 0.1 L | 3.2 | 3.2 | 0.2 | 1.4 | 0.4 | 1.3 |
| 2055 | abietatriene | 1.3 | 1.5 | 1.7 | 1.1 | 1.1 | 0.5 | 0.9 | 1.6 | 2.5 |
| 2087 | abietadiene | t | t | 0.1 | t | t | 3.0 H | t | 5.4 H | t |
| 2105 | isoabienol | 1.8 | 1.8 | 6.0 H | 1.5 | 1.5 | 1.4 | 0.9 | 0.9 | 1.2 |
| 2149 | abienol | 2.3 | 0.7 | 1.2 | 1.7 | 1.7 | 3.2 | 0.4 | 0.8 | 0.2 |
| 2179 | abienol isomer | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 | t | t | t | t |
| 2269 | sandaracopimarinol | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | t | 0.2 | t |
| 2282 | sempervirol | 0.1 | 0.1 | 0.3 | 0.2 | 0.2 | t | t | t | t |
| 2314 | trans-totarol | 3.0 | 2.7 | 3.5 | 3.0 | 3.0 | 5.5 H | 1.9 | 1.4 | 0.8 |
| 2331 | trans-ferruginol | 0.4 | 0.4 | 0.7 | 0.4 | 0.4 | 0.7 | 0.4 | 0.2 | t |

KI = linear Kovats Index on DB-5 column. Compositional values less than 0.1% are denoted as traces (t). Unidentified components less than 0.5% are not reported.